

Predatory Behavior and Diet of *Eupleura sulcidentata* Dall, 1890 (Gastropoda: Muricidae) from West Florida

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Abstract. The diet and feeding behavior of the muricid gastropod *Eupleura sulcidentata* are documented for the first time from laboratory aquarium experiments. *Eupleura sulcidentata* feeds readily on a broad range of shelled invertebrate prey, including barnacles, bivalves and calyptraeid gastropods, by drilling. Drillholes are small (<1 mm) but tend to have beveled sides, a morphology generally regarded as diagnostic of naticid drillholes.

Key Words: Gastropoda, Muricidae, *Eupleura*, predation, diet.

The present study contributes new observations on the diet and feeding behaviors of *Eupleura sulcidentata* Dall, 1890, a diminutive species of ocenebrine muricid with a range that extends from Florida to the Bahamas and northern Cuba. Previously, the feeding biology of this species was studied by Radwin and Wells (1968), who found *E. sulcidentata* difficult to maintain in captivity. In their experiments, *E. sulcidentata* predators were offered several types of invertebrate prey, including the bivalves *Crassostrea virginica*, *Ostrea equestris*, and *Brachidontes exustus*, and two barnacles, but refused all five and eventually died without feeding.

Predatory gastropods of the family Muricidae are well known for their capacity to drill holes in shelled invertebrate prey (Carriker, 1961, 1981; Carriker and Gruber, 1999; Carriker et al., 1974), but many muricids employ additional (or alternative) modes of food acquisition, including use of anesthetizing toxins (West et al., 1994; Roller et al., 1995), mechanical shell breaking and wedging (Wells, 1958; Dunkin and Hughes, 1984; Perry, 1985), ovophagy (Philipps, 1969; Taylor, 1976; Abe, 1983), kleptoparasitism (Ishida, 2001, 2004), carrion feeding (Wu, 1965; Morton, 1994), and true parasitism (Ward, 1965; Robertson, 1970; Matsukuma, 1977). Given this diversity, it is possible that *E. sulcidentata* is an obligate non-driller specializing on prey other than those provided by Radwin and Wells (1968).

As an initial test of this hypothesis, we repeated the Radwin and Wells experiment using prey known to occur in the same microhabitat as *E. sulcidentata*. At least one of the prey species offered in the Radwin and Wells study, the oyster *C. virginica*, lives in muddier, lower salinity waters of the upper estuary, whereas *E. sulcidentata* is found only in sandier, normal marine

conditions of the lower estuary and shallow coast. Thus, in at least one case, *E. sulcidentata* may have simply been refusing an unfamiliar prey.

Although *E. sulcidentata* is not uncommon, its cryptic microhabitat makes it difficult to observe its feeding preferences and behaviors in the field. In Tampa Bay, Florida, *E. sulcidentata* is most common in tidal channels between mangrove islands, where the channels are paved with the disarticulated valves of the venerid clam *Mercenaria campechiensis* (Gmelin, 1791). When oriented in a hydrodynamically-stable, concave-down position, large *Mercenaria* valves create a cave-like domicile for *E. sulcidentata* and numerous other small invertebrates. Because of their local abundance and close proximity to *E. sulcidentata*, these other invertebrates are the most likely components of the diet of *E. sulcidentata*.

Predators and prey in this experiment were collected between December 2005 and February 2006 in 1–2 m of water from Miguel Bay, in the southernmost region of Tampa Bay, Florida and transferred to a laboratory at the University of South Florida in Tampa. Six *E. sulcidentata*, all roughly 20 mm in shell length (maximum shell length of this species) and presumably mature, were collected from the field site, all of them underneath overturned *Mercenaria* valves. Nine shelled invertebrates encountered with *E. sulcidentata* predators in this microhabitat were collected and offered as food in this experiment, including the barnacle *Balanus eburneus* Gould, 1841; five species of bivalve: *Ostrea equestris* Say, *Brachidontes exustus* (Linnaeus, 1758), *Timoclea grus* (Holmes, 1858), *Lyonsia floridana* Conrad, 1849, and *Anomalocardia auberiana* (d'Orbigny, 1842); two species of slipper limpet: *Bostrycapulus aculeatus* (Gmelin, 1791) and a member of the

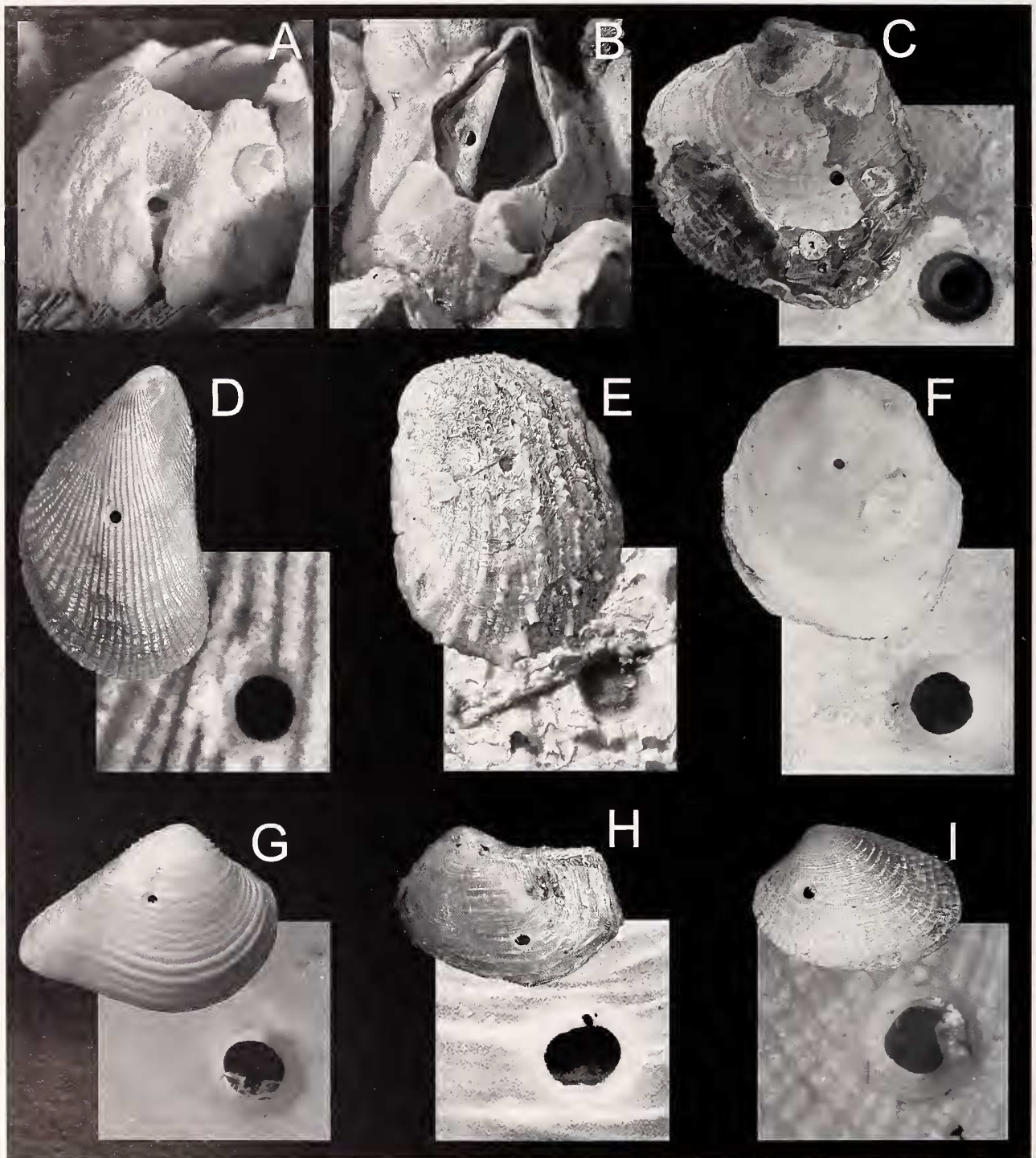


Figure 1. Examples of predatory drillholes produced by the muricid gastropod *Eupleura sulcidentata* in barnacle, bivalve, and gastropod prey. Length measurements are for the anterior-posterior shell axis unless otherwise stated. A. *Balanus eburneus* (height 4.3 mm). B. *Balanus eburneus* (height 5.1 mm). C. *Ostrea equestris* (15.2 mm). D. *Brachidontes exstis* (5.9 mm). E. *Bostrycapulus aculeatus* (14.4 mm). F. *Crepidula depressa* (15.5 mm). G. *Anomalocardia auferiana* (13.2 mm). H. *Lyonsia floridana* (6.9 mm). I. *Timoclea grus* (7.3 mm).

Crepidula plana species complex, probably *Crepidula depressa* Say, 1822 (see Collin 2001), and the chiton *Isnochiton papillosus* (C. B. Adams, 1845).

The six predators were housed in a single 10-gallon laboratory aquarium with recirculating seawater (changed weekly) from the bay. Seawater was maintained at a constant salinity of 35 ppt and a temperature of 15–18°C to mimic conditions at the field site during the time of collection. Within the aquarium, predators were isolated from one another by placing each in its own 10 × 7 × 5 cm clear plastic box into which ten 0.5 cm diameter holes had been drilled. The holes provided ample water circulation, and the box is approximately the same volume as the cryptic microenvironment beneath disarticulated *Mercenaria* valves. The boxes also allowed us to observe the activities of individual predators and monitor the feeding experiments continuously.

Prey were offered one species at a time to predator boxes, except for *Crepidula* and *Bostrycapulus*, which were collected on the same *Mercenaria* valve and offered simultaneously to a single predator. Cemented prey, such as oysters and barnacles, and sessile, loosely attached prey, such as *Brachidontes* and *Crepidula*, which were found attached to the interiors of *Mercenaria* shells, were introduced to the boxes on the original *Mercenaria* shell cut down to 5 cm² pieces.

All dead prey shells were removed prior to introducing the *Mercenaria* piece to the predator. *Anomalocardia*, which is free-living and shallowly infaunal, was added to a box with sand 1 cm deep to allow natural burial and to determine whether the predator could excavate buried prey. Feeding experiments were monitored over a 2-month period, and predated shells were removed daily.

Eupleura sulcidentata fed readily upon eight of the nine prey species offered, the exception being the highly mobile *Isnochiton papillosus*, which was never attacked and experienced no mortality during the experiment. All other prey species were successfully drilled and eaten, in contrast to the results of the Radwin and Wells (1968) experiment. *Eupleura sulcidentata* predators produced drillholes with a mean outer borehole diameter of 0.57 mm ± 0.085 (n = 40) and, in most cases, beveled sides (i.e., a naticid-like morphology). Drillholes in *Anomalocardia* were more often straight-sided (i.e., a more typical muricid-like morphology), but this was still variable depending on local shell thickness at the site of the drillhole. Thus, *E. sulcidentata* joins the growing list of muricid gastropods capable of drilling beveled naticid-like drillholes (see also Edward et. al., 1992; Gordillo and Amuchástegui, 1998; Carriker and Yochelson, 1968).

Predators selected drilling sites away from the prey shell margins for attacks on bivalves and slipper limpets. However, 50% of barnacle prey consumed (n

= 8) were edge drilling attacks between wall plates. Only one attack on *B. eburneus* was a drillhole through a wall (lateral plate), and the remainder (n = 3) were drillholes through the beak (scutum). The more refined attack behaviors used against barnacles suggests that *E. sulcidentata* may specialize on this prey type in the wild.

For drilling attacks recorded on the slipper limpets *C. depressa* and *B. aculeatus*, 42% (5/12) resulted in incomplete drillholes and unsuccessful attacks. No obvious defensive responses by the slipper limpets were observed during the course of the experiment, although all were mobile and periodically changed their position on the *Mercenaria* shell or even moved onto the interior of the plastic box. The ratio of incomplete drillholes to total drilling attempts was higher for the spiny *Bostrycapulus* (67%, 2/3) than the smooth surfaced *Crepidula* (33%, 3/9), although these numbers are not statistically significant. It is notable, however, that the predator offered the slipper limpets selectively drilled all of the non-spiny *C. depressa* first. Only when the nine unornamented *C. depressa* had been eliminated from its box did *E. sulcidentata* begin to attack and drill the spiny *Bostrycapulus*.

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LITERATURE CITED

- ABE, N. 1983. Breeding of *Thais clavigera* (Kuster) and predation of its eggs by *Cronia margariticola* (Broderip). Pp. 381–392 in B. Morton & D. Dudgeon (eds.), The malacofauna of Hong Kong and southern China III. Hong Kong University Press: Hong Kong.
- CARRIKER, M. R. 1961. Comparative functional morphology of boring mechanism in gastropods. *American Zoologist* 1:263–266.
- CARRIKER, M. R. 1981. Shell penetration and feeding by naticacean and muricacean predatory gastropods: a synthesis. *Malacologia* 20:403–422.
- CARRIKER, M. R. & G. L. GRUBER. 1999. Uniqueness of the gastropod accessory boring organ (ABO): comparative biology, an update. *Journal of Shellfish Research* 18:579–595.
- CARRIKER, M. R., J. G. SCHAADT & V. PETERS. 1974. Analysis by slow-motion picture photography and scanning electron microscopy of radular function in *Urosalpinx cinerea follyensis* (Muricidae, Gastropoda) during shell penetration. *Marine Biology* 25:63–76.
- CARRIKER, M. R. & E. L. YOCHELSON. 1968. Recent gastropod boreholes and Ordovician cylindrical borings. U.S. Geol. Surv. Prof. Pap. 593-B, 26 pp.
- COLLIN, R. 2003. Phylogenetic relationships among Calyptraeid gastropods and their implications for the biogeography of marine speciation. *Systematic Biology* 52:618–640.
- DUNKIN, S. DE B. & R. N. HUGHES. 1984. Behavioural components of prey-selection by dogwhelks, *Nucella lapillus* (L.) feeding on barnacles, *Semibalanus balanoides*

- (L.) in the laboratory. *Journal of Experimental Marine Biology and Ecology* 79:91–103.
- EDWARD, J. K. P., M. X. RAMESH & K. AYAKKANNU. 1992. Comparative study of holes in bivalves, chipped and bored by the muricid gastropods *Chicoreus ramosus*, *Chicoreus virgineus* and *Murex tribulus*. Phuket Marine Biological Center Special Publication 11:106–110.
- GORDILLO, S. & S. N. AMUCHÁSTEGUI. 1998. Estrategias de depredación del gastrópodo perforador *Trophon geversianus* (Pallas) (Muricoidea:Trophonidae). *Malacologia* 39: 83–91.
- ISHIDA, S. 2001. An analysis of feeding aggregations in intertidal muricids: species-specific mode of foraging-initial predation and parasitism. *Asian marine biology* 18: 1–13.
- ISHIDA, S. 2004. Initial predation and parasitism by muricid whelks demonstrated by the correspondence between drilled holes and their apparent envelope. *Journal of Experimental Marine Biology and Ecology* 305:233–245.
- MATSUKUMA, A. 1977. Notes on *Genkaimurex varicosa* (Kuroda, 1953) (Prosobranchia: Neogastropoda). *Venus* 36:81–88.
- MORTON, B. 1994. Prey preference and method of attack by *Rapana bezoar* (Gastropoda: Muricidae) from Hong Kong. Pp. 309–325 in B. Morton (ed.), *The malacofauna of Hong Kong and southern China III*. Hong Kong University Press: Hong Kong.
- PERRY, D. M. 1985. Function of shell spine in the predaceous rocky intertidal snail *Acanthina spirata* (Prosobranchia: Muricacea). *Marine Biology* 88:51–58.
- PHILLIPS, B. F. 1969. The population ecology of the whelk *Dicathais aegrota* in western Australia. *Australian Journal of Marine and Freshwater Research* 20: 225–265.
- RADWIN, G. E. & H. W. WELLS. 1968. Comparative radular morphology and feeding habits of muricid gastropods from the Gulf of Mexico. *Bulletin of Marine Science* 18: 72–85.
- ROBERTSON, R. 1970. Review of the predators and parasites of stony corals, with special reference to symbiotic prosobranch gastropods. *Pacific Science* 24:43–54.
- ROLLER, R. A., J. D. RICKETT & W. B. STICKLE. 1995. The hypobranchial gland of the estuarine snail *Stramonita haemastoma canaliculata* (Gray) (Prosobranchia: Muricidae): a light and electron microscope study. *American Malacological Bulletin* 11:177–190.
- TAYLOR, J. D. 1976. Habitats, abundance and diet of muricacean gastropods at Aldabra Atoll. *Zoological Journal of the Linnean Society* 59:155–193.
- WARD, J. 1965. The digestive tract and its relation to feeding habits in the stenoglossan prosobranch *Coralliophila abbreviata* (Lamarck) [sic]. *Canadian Journal of Zoology* 43:447–464.
- WELLS, H. W. 1958. Feeding habits of *Murex fulvescens*. *Ecology* 39:556–558.
- WEST, D. J., E. B. ANDREWS, A. R. MCVEAN, D. J. OSBORNE & M. C. THORNDYKE. 1994. Isolation of serotonin from the accessory salivary glands of the marine snail *Nucella lapillus*. *Toxicon* 32:1261–1264.
- WU, S. K. 1965a. Comparative functional studies of the digestive system of the muricid gastropods *Drupa ricinia* and *Morula granulata*. *Malacologia* 3:211–233.